LOB #368:

CONVEYANCE SYSTEM REHABILITATION PROJECTS

Purpose

The stormwater conveyance system exists to safely transport rainwater in the County's communities to natural streams, minimizing localized flooding in and near dwellings, buildings and roads. The County is responsible for the operation and maintenance of the storm drainage conveyance systems within County-owned properties, in easements located in residential areas and for through drainage across commercial, institutional and industrial properties. The purpose of the Conveyance System Rehabilitation Projects is to affect the full and complete operation, maintenance and renewal of the storm drainage conveyance infrastructure. These renewal projects help to protect the property of County residents and natural resources by addressing deficiencies before failure occurs with greater damage, maintaining the value of the County's infrastructure and utilizing innovative technology in its service delivery. By focusing resources on the highest prioritized infrastructure assets, significant cost savings can be realized where resources are placed on assets that are about to fail rather than reacting to a system failure when increased resources would be required.

Description

The Maintenance and Stormwater Management Division (MSMD) operates and maintains approximately 1,400 miles of County-owned underground stormwater pipes, structures, outfalls and improved channels that have an estimated replacement value of nearly $1.3 billion. Services are provided to manage the conveyance of stormwater runoff, mitigate localized flooding and improve water quality from the storm conveyance systems in support of healthy communities, environmental stewardship and as required by state and federal permits, Municipal Separate Storm Sewer System (MS4), as well as local ordinances and codes.

Because of the growing, aging, and failing storm drainage assets, during FY 2010, the Department of Public Works and Environmental Services, through MSMD, began developing and implementing a comprehensive storm drainage asset management program. The primary goal of the Storm Drainage Infrastructure Reinvestment Program (SDIRP) is to establish a sustainable asset management program for the effective operation, maintenance and renewal of the County's storm drainage conveyance system. A sustainable program is envisioned to be one where the most effective use of funds is realized through optimizing the life of the drainage assets before renewal is required as a result of failure, in other words, to operate a program, which is more proactive and minimizes reactive work.

The County land development regulations for storm conveyance system installations date back to the 1940s, and continue to evolve, in many cases in reaction to comply with new state and federal mandates and regulations. Recently renewed permits (MS4) mandate increased compliance requirements not just in flood protection, but in water quality improvements to these "out of sight, out of mind" buried systems. Most of the conveyance systems are acquired through the land development process and are beginning to reach their original expected life cycle of 75 years. MSMD has struggled to minimize system failures, since an accurate assessment of the whole storm system network has not been completed, thus, not allowing repairs to the components before failure. It is the goal of the SDIRP to become a pro-active program where the maximum life of the storm drainage assets (storm pipes and catch basins) is realized prior to their failure. It costs more to be in a reactive mode than it does to be proactive, the reason to have a managed asset management program.

There are several components of the SDIRP:

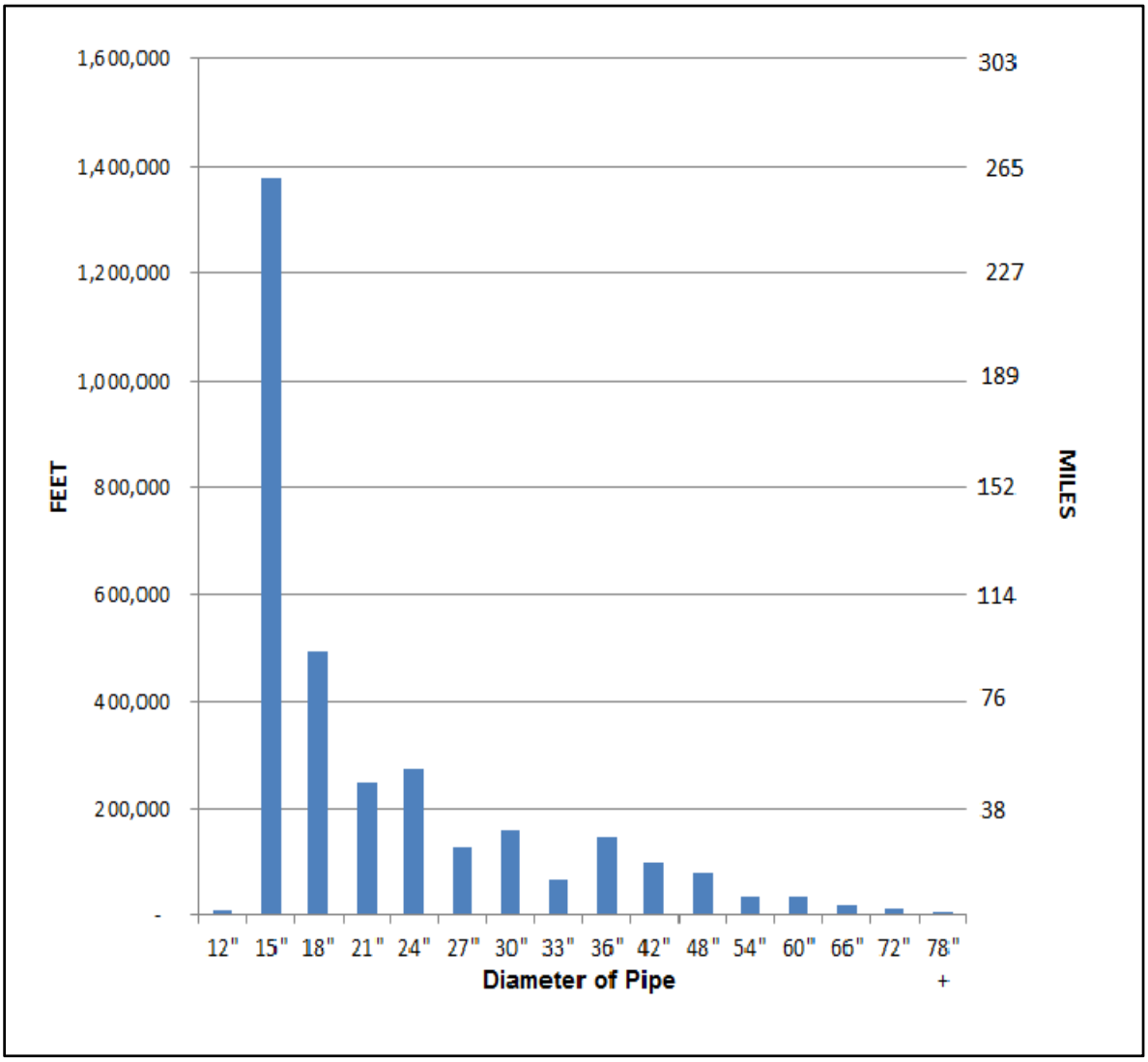
- ***Inventory*** – It is important to know what types and how many storm conveyance systems belong to the County. The SDIRP utilizes the County's GIS (Geographic Information Systems) as its asset inventory repository. The map location and physical characteristics of each separate pipe segment, storm structure (including MS4 outfalls), and channel is captured and the StormNet layer now includes linkages to recorded easements, which are used to identify the asset as an ongoing operation and maintenance responsibility of the County. The inventory's easement layer was substantially completed during FY 2009. The MS4 permit requires that the inventory be continuously updated.

Current Inventory of Storm Conveyance Systems

System Description	Approximate Quantity	Units of Measure
Pipes	1,286	miles
Structures	60,320	each
Outfalls	6,782	each
MS4 outfalls	5,880	each
Improved channels	91	miles
Floodplain Easement Area	8,243	acres

The GIS is continuously updated with newly constructed assets and are reported annually in compliance with Government Accounting Standards Board (GASB) regulations. Increased MS4 permit regulations also require continuous update and reporting of the inventory. Compliance with the updates of the inventory requirement is met under the Condition Assessment described below. The completed condition assessment (about 600 miles of the 1,286 mile system) shows that the storm pipes range from 12" to 78" diameter where approximately half of the pipes are 15" diameter.

Mileage of Storm Pipes with Completed Condition Assessment by Pipe Size



- ***Condition Assessment:*** An assessment allows the County to get the most use out of the conveyance system components/assets and to be able to predict failure before it happens and anticipate when it will happen. A failed pipe is defined as one that is no longer providing safe conveyance of stormwater flow at its original design capacity. To understand the current condition of the pipe systems from the closed-circuit television (CCTV) effort, the program's staff are finding various performance issues, determining remaining useful life and estimating the economic value. A goal of the SDIRP is to video inspect and assess the almost 1,300 miles of inventory by FY 2019.
  - The internal pipe condition assessment results conducted with CCTV equipment continue to show that about 3.5 percent of the pipes are in complete failure (pipe joint separation and misalignment, broken and crushed pipe causing blockages, cave-ins, etc.) and an additional 10 percent require immediate repair or maintenance. Using CCTV to view the internal condition of the storm pipe system, the program's staff is learning how the pipe systems are failing. There are two classifications of condition assessment: Operation and Maintenance (O&M), typically including blockages caused by debris in the system, repairs of a safety hazard such as a cave-in, and replacing a missing manhole covers, and Structural, typically including blockages caused by broken or collapsed pipes and severe erosion and undermining in open channels and streams.

- Increased MS4 permit regulations require periodic (5-year cycle) inspections to identify and eliminate potential sources of water quality degradation as well as continuously updating the inventory. Staff walks the ground surface above the pipe systems to complete a visual condition assessment inspection of the buried system for failures such as cave-ins, encroachments, and damaged or missing components which are a safety or operation concern to the citizenry.
- From the walking surveys, the defects in the storm structures are identified and classified as O&M and/or structural.
- Using CCTV cameras, the defects in the pipe systems are identified and classified as O&M and/or structural.
- As a result of the CCTV and the walking surveys, the pipe size, lengths and connectivity is continuously validated and updated in the GIS inventory layer.
- As the condition assessment is completed, a grading scheme is applied to each storm pipe segment and structure. This allows determination of the degree of failure each pipe or structure is in.
- With the inventory information on each asset and its characteristics, the completed condition assessment allows staff to determine failure rates, which then are used to predict failure on the newer assets and to implement changes in codes and specifications, which would lead to reduction of similar future occurrences.
- After the initial, first-time condition assessment is complete, the internal video condition assessment inspection will be transitioned into one where the review is conducted on a 20-year cycle, which is expected to occur during FY 2018.
- In addition to the internal video pipe inspections, MSMD staff continues to physically walk and inspect an average of 20 percent of the storm drainage inventory annually, for external pipe system failures and deficiencies such as cave-ins, blockages and structural failures, which is also required under the MS4 permit.
- Condition assessment conducted in response to severe weather events and natural disasters such as hurricanes, tornadoes, floods, hazardous material spills, etc., result in reprioritizing O&M activities as well as structuring redesign projects.

- ***Infrastructure Renewal*** – As the SDIRP grows into a sustainable program, it has to continue to balance the environmental regulations and social needs of the community with the economic constraints of the program resources. To select projects for funding, given limited resources, from the condition assessment inspections, each asset is scored following a set prioritization scheme that takes into account many criteria, including:

  - Potential to meet water quality improvement targets
  - Restoration of design capacity
  - Criticality to safe operation of the system
  - Life Cycle of the asset – Most of the storm pipes in the inventory are constructed with reinforced concrete, which has an expected life cycle of 100 years. The life expectance of corrugated metal pipe is 25-30 years, which makes up the remainder of the inventory
  - Potential to fail
  - Knowledge that age of the asset is not the primary likelihood of failure
  - Replacement costs – recent renewal project costs average near $1 million/mile
  - Reducing risk or the consequence of system failure, avoiding higher emergency repair costs
  - Identifying critical assets that are core to sustained performance

The SDIRP is incorporating a process where each storm pipe, structure and man-made channel is evaluated and ranked for necessity of renewal that is based on failure state (likelihood of failure) and criticality for service disruption should failure occur (consequence of failure), and then prioritized for renewal. This allows the program to address the worst cases first where limited funds can be focused on the projects in most need of addressing while costs are much less than the repairs of a failed asset. This saves significant program resources, allowing additional deficiencies to be addressed. Acceptable industry standards indicate that one dollar re-invested in infrastructure saves seven dollars in the asset's life and $70 if asset failure occurs.

The benefit of following a set prioritization scheme in operating the SDIRP is that it can be scalable to the available resources while spending resources on the most critical assets, while allowing for diverting resources to emergency situations and failed systems.

Annual Expenditures ($)		
	Condition Assessment	**Renewal Projects**
FY 2012	158,458	1,103,050
FY 2013	445,484	1,399,162
FY 2014	875,364	4,467,235
FY 2015	931,497	2,447,892

- ***Optimizing the Program*** – It is recognized that there are several items to consider while transitioning from a reactive program to a sustainable proactive program:

  - the quantity and sizes of assets in the inventory
  - the condition they are in using the defect scoring
  - the remaining life of each asset
  - the knowledge that has been gained about failures and how they happen
  - the levels of service that the program strives to maintain with the citizenry
  - the historical costs of operation and maintenance
  - the claim risk associated with asset failure
  - the costs of repair, rehabilitation and replacement alternatives
  - the projected O&M needs

Program staff can identify critical assets using a set of prioritization schemes. This helps identify how and where to effectively focus limited resources to maximize the life of the storm conveyance system components and renew them timely to avoid the higher cost resulting from failure. By focusing resources on the highest prioritized assets, significant cost savings can be realized where resources are placed on assets that are about to fail rather than reacting to a system failure when increased resources would be required.

Benefits

The Storm Conveyance Rehabilitation Projects are the foundation that supports the mission of Stormwater Management by:

- Developing a sustainable community where the level of service to maintain and renew the storm conveyance infrastructure is balanced with environmental constraints, regulatory requirements and available resources.
- Protecting the environment by addressing in a timely manner failed and failing conveyance systems to protect from property loss and damage.
- Working to provide an ideal place to live in by maintaining the storm infrastructure at its optimal capacity.
- Excelling in public service by implementing timely and cost-effective solutions.
- Seeking and using innovative solutions that are sensitive to the environment while achieving the purpose of the infrastructure systems.

Specific benefits realized include:

- Providing continuous and safe operation of existing infrastructure by preventing cave-ins and sink holes, renewing, repairing and filling them as necessary, and replacing missing manhole covers.
- Minimized house, yard and road flooding occurrences by providing increasing capacity of the conveyance system or redesigning runoff controls that mitigate property damage.
- Minimized property loss from stream erosion by using stream stabilization techniques and natural channel design concepts.
- Maintaining the storm conveyance assets to provide cleared, unobstructed flows and operate at maximum capacity.
- Cost-effective solutions that renew and extend the life of existing infrastructure.
- Solutions that are sensitive to and protect the environment and water quality.
- Reduced claims to the County.
- Citizen enjoyment of their safe and healthy communities.
- Reduction in the number of trouble spots where flood mitigation and outfall stabilization projects are implemented and where re-active maintenance is reduced.
- The ongoing maintenance projects keep the storm system in an optimized operational state. The condition assessment program alerts staff to deficiencies that exist or are beginning to develop in these “out of sight, out of mind” assets, and allows staff to identify and address potential failures that impact safety, health and property values of County residents.
- The conveyance system rehabilitation projects serve to provide operation, maintenance and renewal services on existing aging and deteriorating stormwater infrastructure such as pipes, catch basins, drainage channels, streams and floodplains. The projects are designed to stabilize and enhance the features of the natural environment while maintaining the County infrastructure. The projects further full operation of the infrastructure while maintaining the property values in the communities.
- The majority of the storm conveyance projects are designed to stabilize and enhance the features of the natural environment while maintaining the existing County infrastructure. The project designs take advantage of trenchless technologies where disruption to the environment is virtually eliminated while renewing pipe systems with materials that extend the asset life just as if the buried pipe was replaced. Open channel work uses channel design techniques that mimic nature and uses natural resource materials such as large stones to guide surface runoff with the receiving streams and floodplains.

Mandates

This LOB complies with the following laws and mandates:

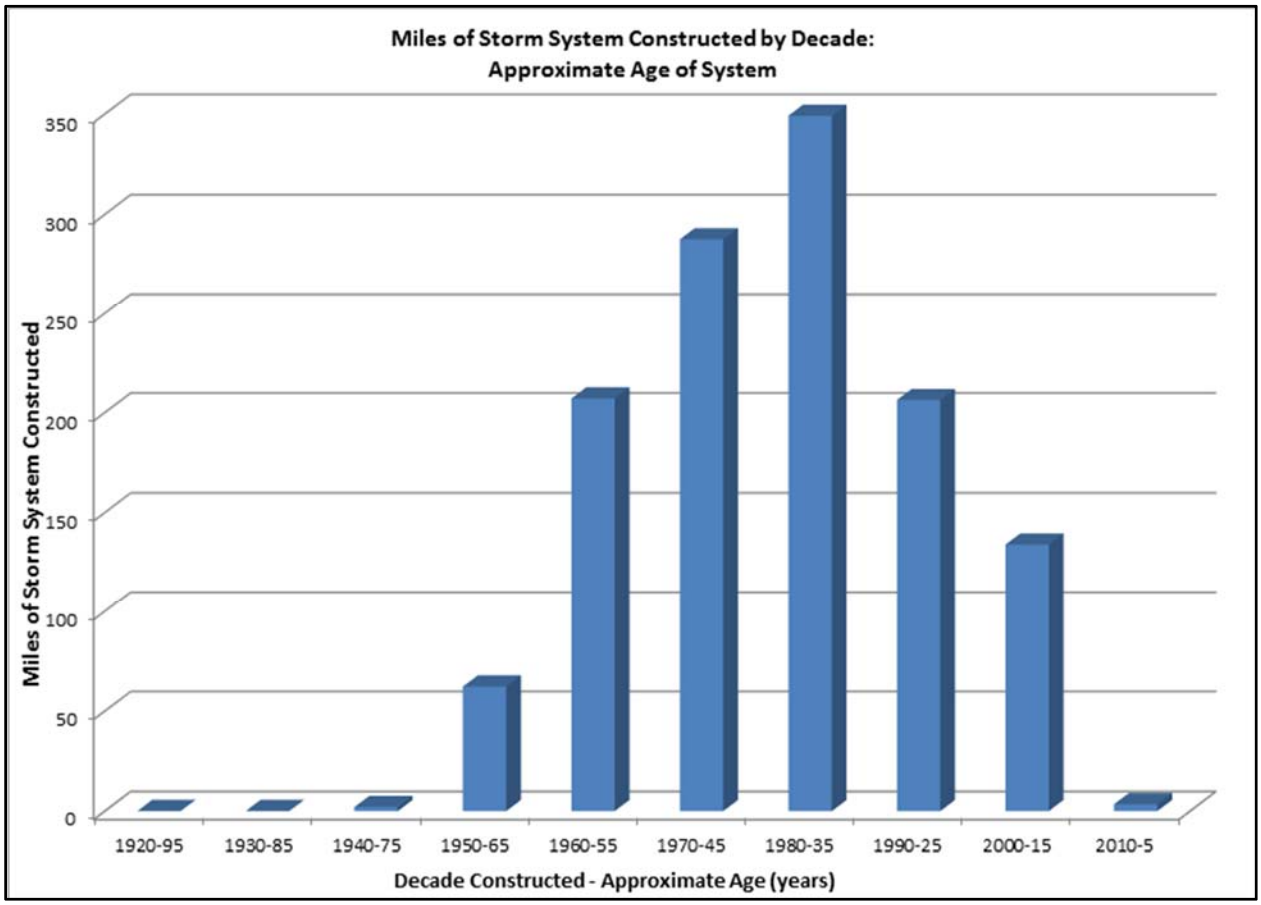
- Chesapeake Bay Preservation Area Designation
- Flood Prevention and Protection Assistance Fund
- Stormwater Management Program
- Erosion and Sediment Control Program
- Federal Clean Water Act
- Local Emergency Operations Plan
- Virginia Pollution Discharge Elimination System Permit
- Virginia Water Protection Permit
- Virginia Pollution Abatement Permit

Trends and Challenges

The conveyance system rehabilitation program provides operation, maintenance and renewal services on existing stormwater infrastructure such as stormwater pipes, catch basins, drainage channels, streams and floodplains. Expanding program requirements, due to both the growth of the systems and to the increased regulatory compliance requirements, are placing extreme challenges on limited in-house staff and resources. Increased regulatory compliance requirements associated with the MS4 permit impose greater controls and mandates for discharging local storm water runoff into state and federal waters, thus forcing the continued operation and function of the storm conveyance systems. The stormwater system is an aging infrastructure that is strained from the continuous urbanization and infill development and redevelopment that is occurring throughout the County. The systems are impacted by increases in the amount of ground surface imperviousness due to development and redevelopment construction of residential housing, roadways, parking lots and commercial building facilities. Stormwater runoff velocities and volumes increase due to these impervious areas, causing the conveyance systems to be frequently overworked and overwhelmed. New storm drainage system performance requirements related to infill and redevelopment are burdening the aged storm drainage infrastructure, also increasing the discharge velocities and volumes carried through natural waterways that the storm drainage systems discharge into. Thus, the conveyance systems are operating at their capacity.

The internal pipe condition assessment results, conducted with CCTV equipment, show that about 3.5 percent of the pipes are in complete failure (pipe joint separation and misalignment, broken and crushed pipe causing blockages, cave-ins, etc.) and an additional 10 percent require immediate repair or maintenance. While the programmatic service levels are managed at consistent levels, increasing inventory and additional regulatory requirements combined with evolving infill development issues reduce service provision.

The findings of the condition assessment program indicate that system failures are not occurring as much from their age as they are occurring from poor construction practices as well as from outside intrusions such as cable bores, unauthorized connections and easement encroachments with structures such as garages, sheds, and fence posts, all of which compromise the integrity of the storm conveyance pipes. These types of failures significantly reduce the storm system component life cycle from 100 years to closer to 50 years for many of the systems. This would indicate that additional resources are needed for renewal projects much sooner than originally anticipated.



The results of the physical condition assessment inspections also indicate that changes may be needed in the construction standards and methods used when infrastructure is first installed. The requirement implemented during 2008 now requires new development to video document the condition of newly constructed systems to insure proper installation, prior to turning the systems over to the County for ongoing maintenance. This is considered a large step toward extending the life cycle of the storm pipe systems as the County's own condition assessment inspections are revealing that the construction deficiencies are a major cause of the premature failures in the County storm conveyance systems acquired through the land development process. The goal of operating the infrastructure reinvestment program is to incorporate the right balance of minimizing risk of failure with expenditure of resources for both the buried pipe systems, and for the streams and channels. As the condition assessment inspection results are analyzed to predict when failure might be predicted, the program can keep the assets in operation as long as possible to realize the benefit of reducing failure occurrences and reducing resources needed for renewal.

Resources

Category	FY 2014 Actual	FY 2015 Actual	FY 2016 Adopted
LOB #368: Conveyance System Rehabilitation Projects			
FUNDING			
Expenditures:			
Capital Projects	$6,222,382	$3,766,425	$6,000,000
Total Expenditures	$6,222,382	$3,766,425	$6,000,000
Total Revenue	$4,500,000	$5,000,000	$6,000,000
POSITIONS			
Authorized Positions/Full-Time Equivalents (FTEs)			
Positions:			
Regular	0 / 0	0 / 0	0 / 0
Total Positions	0 / 0	0 / 0	0 / 0

Metrics

Metric Indicator	FY 2013 Actual	FY 2014 Actual	FY 2015 Actual	FY 2016 Estimate	FY 2017 Estimate
Number of miles of internal storm pipe video completed (cumulative percentage complete)	99.1 (14.2%)	212 (30.6%)	202.4 (46.4%)	225 (63.7%)	250 (83.1%)
Number of miles of storm pipe renewed	1.65	4.32	2.02	4.00	5.00
Cost per mile of storm pipe renewed	$849,830	$1,011,759	$947,241	$1,000,000	$1,002,000
Percent of storm conveyance system renewed annually	0.13	0.34	0.16	0.31	0.39
Ratio of miles of storm conveyance system renewed proactively to miles of system renewed reactively	1.89 (1.08/0.57)	1.34 (2.47/1.85)	1.81 (1.30/0.72)	2.0	2.1

One of the first goals of establishing a sustainable asset management program is to know what assets the County has and what condition they are in. Since the condition of the pipe system has never been observed from the inside, staff needs to determine whether there are existing failures or whether there are failures about to occur. As a program strategy, it is necessary to obtain this initial condition assessment as soon as resources allow, which will help determine the program capital operation, maintenance and renewal needs. Therefore, a goal of completing this initial assessment within 8 years was developed.

The number of miles of internal pipe inspection completed and the cumulative completed percentage of the entire system being inspected for the first time is projected to increase. Once the initial assessment is completed, staff will prioritize the pipes for inspection and roll into a 20-year inspection cycle.

With contracted resources in place and the program's annual completion rate increasing slightly, it is expected that the initial condition assessment inspections will be completed prior to FY 2019. Balancing resources to address the immediate operation and maintenance as well as renewal needs is becoming more difficult, and is driving the need for use of the prioritization scheme. Use of the prioritization scheme has been beneficial in the sense that the pipes in the worst condition or which have failed are getting the needed attention within the limited resources available.

The number of miles of storm pipe renewed represents the annual accomplishment of pipe renewal in miles where the target should be equal to approximately 13 miles/year (including anticipated growth), which is based on a 100-year life cycle of storm pipes.

With the initial life cycle of a pipe system estimated at 100 years, the program's targets are to provide a sustainable program and to annually renew 1 percent of the system, or about 13 miles/year with almost 1,300 miles of pipes in the inventory. As the results of the condition assessment efforts are tabulated into the prioritization model, staff are able to renew the failed pipe systems as well as address deficiencies resulting from emergency or severe storm events. The initial condition assessment has been completed on about one half of the entire inventory. With that information collected, it has been observed that about 3.5 percent of the system has failed or is failing and is in need of some level of maintenance or renewal. With contracted and staff resources in place along with the prioritization scheme, current funding levels limit how much can be focused on renewal. Priority is placed on failed assets, which generally cost more to repair because of additional property damage, and remaining resources are put into projects which are more proactive in anticipating failure before failure occurs. During FY 2015, two miles of storm pipes were renewed. There is an increasing need to increase the annual funding in this program to address the 3.5 percent of the system in failure mode to avoid increased costs, which could be seven-fold from addressing the needs before failure.

As the assets are beginning to reach their expected 100-year life cycle and staff are finding that construction issues are the major contributor to failure, now is the time to address failing assets and be ahead of emergency repairs and excess property damage.

The cost per mile of storm pipe renewed represents the average cost per mile to renew storm pipe systems. Many factors contribute to the cost of a renewal project such as pipe size, its depth in the ground, the land use above it, etc. The historical average cost can be used to project the future needs in operating a sustainable program. It would be expected that the average costs would increase with inflation, just as any construction project would. Staff is taking advantage of innovative technologies that are sensitive to the citizen needs where disruption to their communities is minimized during construction, and the need for restoration is virtually eliminated. In many cases, the value to the citizen cannot be measured using the cost of a project or the available alternatives.

The percent of storm conveyance system renewed annually measures how well staff is keeping up with maintaining and repairing the storm infrastructure in comparison with the expected life cycle of each component of the system. With the initial life cycle of concrete storm pipe at 100 years, it is expected that 1 percent of the system should be renewed on an annual basis. The results are trending upward toward the target of 1 percent where the program is currently at about one-third of the way to the target. The upward trend is a result of increased funding toward renewal projects during the most recent years and the efforts to develop and operate a sustainable program. As the initial condition assessment inspections are completed, a proportion of the resources allocated to condition assessment will be directed toward the maintenance and renewal elements of the infrastructure reinvestment program.

These values indicate that the program is presently not operating at an optimal level. Because the oldest system's components are 75-95 years old and the life cycle of already renewed components is close to 50 years, it is clear that the program needs to continue to grow during the next 5-10 years to get to a state where it is sustainable. It is critical that staff resources grow with the program funding levels. A typical renewed mile of pipe currently requires over 30 task orders to be written and executed.

The ratio of miles of storm conveyance system renewed proactively to miles of system renewed reactively measures how well and how fast the staff is moving from operating a reactive program to operating a proactive program. These annual values should trend upward, indicating the program is becoming more proactive and less reactive. An increase in the value difference from year to year would indicate how fast the program is changing. A reactive program is one where resources are spent on remedying emergencies or system failures that have already occurred. The benefits of being proactive are saving monetary resources by avoiding restoration of property damage, higher construction costs because of the emergency nature of the damages, and claims as a result of flooding and erosion. Past industry standards indicate that one dollar re-invested in infrastructure saves seven dollars in the asset's life and $70 if asset failure occurs. If the value of this ratio becomes a fraction, it would indicate that the program's resources are primarily being spent on already failed systems. A very high value, which is anything greater than 3, would indicate that the program is being very proactive and ahead of failed assets.

To date, condition assessment inspections have been completed on about half of the County's system. Being that the components of the storm conveyance system are buried, the citizens don't see them in their normal daily lives. Oftentimes the failure doesn't 'surface' until after a significant storm event. The results of the internal camera inspections provide staff an estimate of just how much of the system is in failure mode. To date, it is estimated that about 3.5 percent of the system is in some state of failure where the next large storm event could trigger a full failure. If staff can avoid putting resources into already failed systems, there could be significantly more resources available to put into renewal of the systems before a failure would occur.